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Art. VIII.—*The North-West Coast of Tasmania.*

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Introduction.

Although several short sections of the North-West Coast of Tasmania have been described briefly in various publications of the Geological Survey of Tasmania (Loftus Hills, 1913; Nye, 1934), and the geology of that part of it lying between West Head and Circular Head has been mapped in some detail (Stephens, 1908), no consecutive account of the coastal features has appeared.

The following notes are based upon observations made by the author during a recent visit to North-West Tasmania, when he had occasion to visit the coastline at a number of points between West Head and Marrawah, in connection with a field study of Tasmanian basaltic rocks. The cost of the field-work was defrayed by grants from the University of Melbourne and the Australian and New Zealand Association for the Advancement of Science.

The North-West Coastline.

The north-west coastline of Tasmania is a compound one, and, from the evidence of raised strandlines and submerged valleys, its submergent and emergent features are due largely to the successive eustatic rises and falls of sea-level during the Glacial and Post-Glacial periods. During the periods of low sea-level the river valleys were deepened to below present sea-level, while during the periods of high sea-level estuarine conditions extended much further inland than at present, and gave rise to high level flood plains, which are now preserved in the river valleys, as paired terraces. No one stage of high or low sea-level was maintained sufficiently long to allow the coastline to mature, so that it is made up of youthful features of submergence combined with youthful features of emergence. East of Devonport features due to submergence tend to dominate, while west of Stanley those due to emergence are the more prominent.

The north-west coastline differs greatly in appearance from that of South-Eastern Tasmania, although the processes involved in their development were identical. This difference is chiefly the result of their different geological structure. In the south-eastern part of the island there is a repeated alternation of narrow belts of relatively non-resistant Trias-Jura and Permo-Carboniferous sediments with narrow belts of highly resistant dolerites, often in the form of dyke-like masses which strike more or less at right angles to the coastline. As a result deep and narrow valleys have been eroded in the confined belts of softer rock, and the dolerite valley walls have tended to keep such streams from combining with one another. Submergence of this region has given rise to a number of long, narrow arms of the sea, separated by steep sided peninsulas that tail off into islands. On account of their original depth, these drowned valleys were not readily silted up.

In the north-west of Tasmania, on the other hand, the rocks offer a much more uniform resistance to erosion over wide areas. Only at widely separated intervals, where very resistant sediments were developed, as in the Asbestos Ranges, the Dial Ranges, and the Dip Ranges, has differential erosion been marked. These ranges form prominent headlands and reaches of rocky coast. In the wide intervening stretches of somewhat less resistant rocks, stream erosion developed wide valley systems, with a trunk river fed by numerous tributaries. Subsequently many of these wide valleys were filled by lava-flows, chiefly basaltic, and completely buried beneath a wide lava-plain. Between West Head and Marrawah (fig. 1) the coastal features are of three general types, each of which is closely related to the geological structures of the region concerned. For convenience these can be referred to as:—

1. Silted Indentations with Prominent Cliffed Headlands.

This type of coastline occurs along the stretch of coast between West Head and Devonport; and between Jacob's Boat Harbour, Rocky Cape and Stanley. It is made up of wide, deep bays, several miles across, which have been cut in belts of relatively resistant sediments (not covered with basalt) bordered by prominent cliffed headlands that have been cut in still more resistant rocks. Bay-mouth bars, and mid-bay bars, have closed off the heads of these bays, and led to their extensive silting up, so that the depths of the original indentations are masked in plans which do not show the topography of the region. It seems possible that these bars may be as much due to emergence as to beach-drifting.

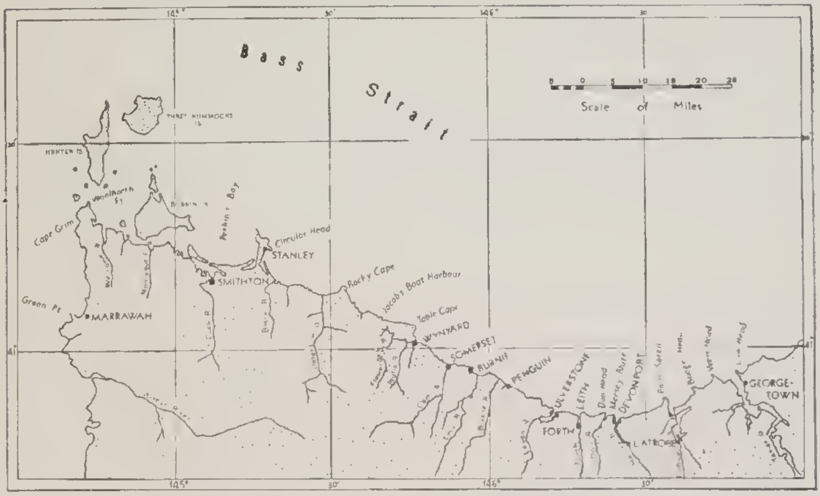

Fig. 1.—Locality Map of the North West Coast of Tasmania.

2. The Scarp Coast.

This extends from Devonport, through Ulverstone, Burnie, Wynyard and Table Cape, as far as Jacob's Boat Harbour; and also occurs in the immediate vicinity of Stanley Peninsula and Marrawah.

Its distinctive feature is the occurrence of a narrow emergent coastal plain, backed by a more or less continuous scarp that sometimes exceeds 200 feet in height. It owes its development to the undercutting by marine erosion of the sheet-like flows of basalt covering the Cambro-Ordovician and Permo-Carboniferous rocks which outcrop at present sea-level in these regions. The basalts in-filled the wide and gently sloping valley systems in these sediments, and formed a plain which rises slowly inland (fig. 2A). Marine erosion of this plain has produced a slowly heightening line of cliffs; and subsequent emergence of the old shore platform to the position of a coastal plain has removed the line of cliff from further attack by the sea, leaving it to weather into a steep escarpment (fig. 2B). Where the major rivers, like the Mersey, Leven and Forth come down to the sea, the coastal plain widens and the scarp shows a corresponding embayment.

The lava-flows in-filling the deeper parts of the old valleys frequently extended below present sea-level, and in a number of places still do. Where the width of lava-filled valley passing below sea-level was not great, marine erosion cut away the valley walls, leaving the basalt-filled valley as a peninsula or narrow headland. Later, however, the encroaching shore platform reached the point where the bottom of the lava-filled valley passed above sea-level. Undercutting followed, and that portion of the lava-filled valley which passed below sea-level was left as an isolated outcrop of basalt on the shore platform (fig. 2B). Where the width of basalt was considerable it remained as an elongated, ridge-like island, such as Stanley Peninsula once was; where the volume of basalt was smaller it became worn down more or less to the level of the shore platform, although it frequently continued to protrude above the platform as rock stacks, like the Doctor's Rocks.

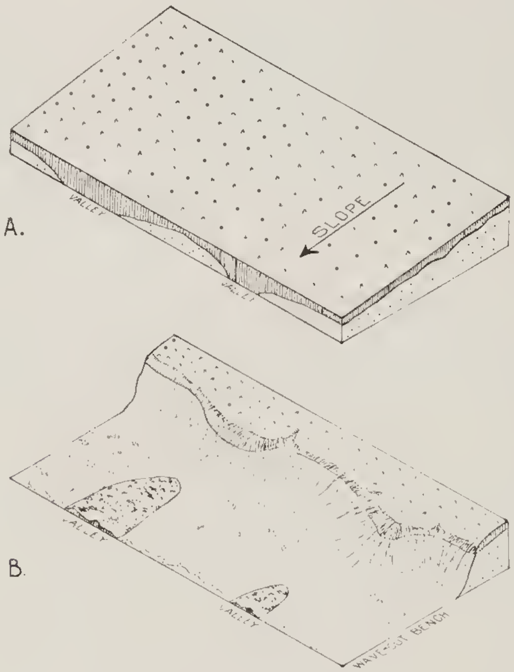

FIG. 2.—Diagram illustrating the formation of the Scarp Coast. A. Basalt plain, before erosion; B. After the formation of a shore platform and subsequent emergence.

Where the width of the lava-filled valley or valleys passing below present sea-level was considerable, as between Table Cape and Jacob's Boat Harbour, or to a lesser degree at Don Heads, the resistant nature of the basalt appears to have restricted the width of such shore platforms as formed prior to the last emergence of the coastal region, and the present phase of marine erosion has removed all but a few traces of them. As a result, along these stretches of the coast the scarp coincides with the present cliffs, which are 200 to 300 feet high. A narrow wave-cut bench has been formed at the base of the cliffs, and is kept free from debris by wave action, while the lower parts of the cliffs show almost vertical slopes (Pl. IX., fig. 3).

3. THE "EMERGENT" COAST.

This variety of coast extends from west of the Stanley Peninsula as far as Marrawah. It is made up of a deeply indented coastline of the first type, fronted by a wide coastal plain of recent emergence, and extensive swamps. Here and there in this plain are hills of resistant rocks which were previously islands, but have been "resumed" with the emergence of the coastal plain.

I. SILTED INDENTATIONS WITH PROMINENT CLIFFED HEADLANDS.

Badger Head Bay: The name Badger Head Bay is used here for the apparently nameless bay between the two prominent headlands of West Head and Badger Head, west of the mouth of the Tamar (fig. 3). West Head is part of a ridge of columnar

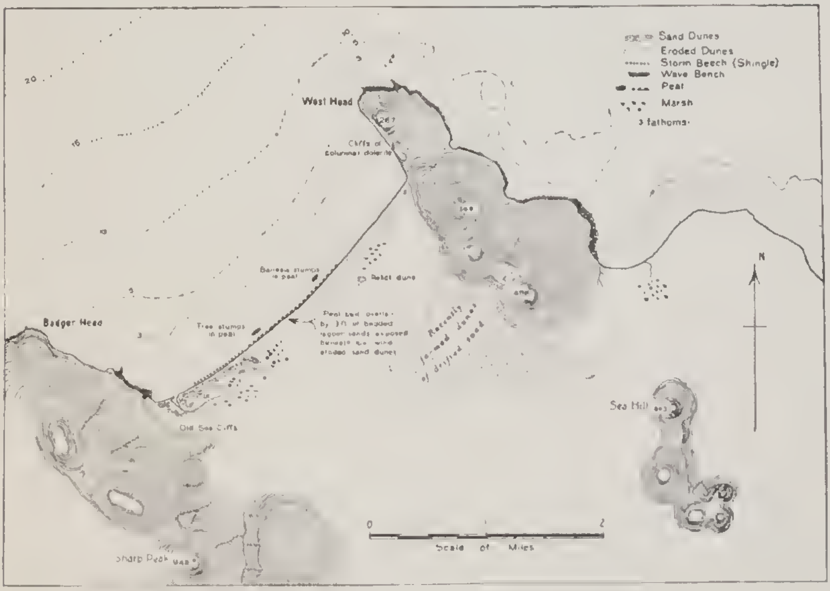

FIG. 3.—Map of Badger Head Bay (adapted from Admiralty Chart No. 3649, Folio 98).

dolerite, which in places forms vertical cliffs over 100 feet high. Badger Head is composed of the overfolded Pre-Cambrian schists and quartzites of the Asbestos Range. Between these two headlands is a beach four miles long, backed by sand dunes. These are protected from north-easterly winds by West Head, but are only partially protected from strong north-westerly winds by Badger Head. At the western end of the beach the dunes are 20 to 30 feet high, and tree covered. About one-third of the way along the beach, going eastwards, they become exposed to winds blowing past Badger Head, and in a distance of about 100 yards a transition takes place from stationary dunes to dune remnants (Pl. VIII., fig. 6) which do not rise more than 3 to 4 feet above the level of the backshore. An occasional partially eroded high dune remains to show that these wind eroded dunes were once as high as those at the western end of the beach. The remaining dunes form ridges more or less parallel to the general wind direction. The sand from the eroded dunes has been blown inland for a distance of several miles, burying the lagoon that existed behind the old dunes, and also accumulating on the western slope of the dolerite ridge that forms West Head.

A storm beach of coarse shingle has been built up to a height of 4 to 6 feet above the high tide level on the backshore, along its central and western part (Pl. VIII., fig. 4); and this protects the bases of the sand dunes from erosion by storm waves. This storm beach has a steep slope to the sea, and a more gentle slope to the dunes, and the pebbles that compose it lie with their flat faces more or less parallel. In places small impermanent lagoons are enclosed between this ridge and the sand dunes.

Swampy conditions exist behind the dunes at the west end of the bay, and once extended the greater length of the bay, where a bed of peat two or more feet thick is exposed beneath a 3-ft. thickness of bedded, iron-stained sand, in the foot of the low cliff, beneath the dune remnants. The iron-stained sands contain grains of buckshot gravel, and a thin layer of buckshot marks the contact of the bedded sand, deposited in the now-buried lagoon, and the sand of the dunes. This peat is also exposed below the storm beach (Pl. VIII., fig. 3), while at low tide two patches of tree stumps and roots (chiefly *Banksia* (?)) set in peat, each covering an area of about 50 square yards, are exposed near the foot of the beach, about 80 to 100 yards from the cliff-face (Pl. VIII., figs. 1, 2, 5).

This indicates that the present recession of the dunes is part of a long continued process; and that previously there was, across Badger Head Bay, a bay-mouth bar which has now been driven in over the lagoon which it enclosed, to the position of a mid-bay bar. The old sea-cliffs, formed prior to the development of the bar, can be observed behind the present marshy lagoon near the western end of the bay.

Several streams run into the bay, and preserve their courses through the sand dunes, but only that one which drains the lagoon at the west end contains permanent water. Eastward drift of sand has deflected its mouth about 100 yards to the east, along the face of the sand dunes. The mouth is closed by a bar; and when this bursts, the dunes on the outside curve of the "meander" caused by the deflection of the stream are energetically undercut and form steep cliffs. The storm beach prevents the deflection of the mouths of the streams crossing the sand smothered area. These streams are dry, except after rain.

Port Sorell and the Rubicon Estuary: Port Sorell is at the mouth of the Rubicon and Franklin Estuary (fig. 4), where these rivers empty into the wide bay to the west of Badger Head. The estuary is tidal for about eight miles upstream from this point. Point Sorell, the west headland of the bay, consists of Mesozoic dolerite. From Hawley to Point Sorell the surface of the dolerite forms a narrow, somewhat marshy, coastal plain, fronted by low sand dunes. This tract, which is 20 to 30 feet

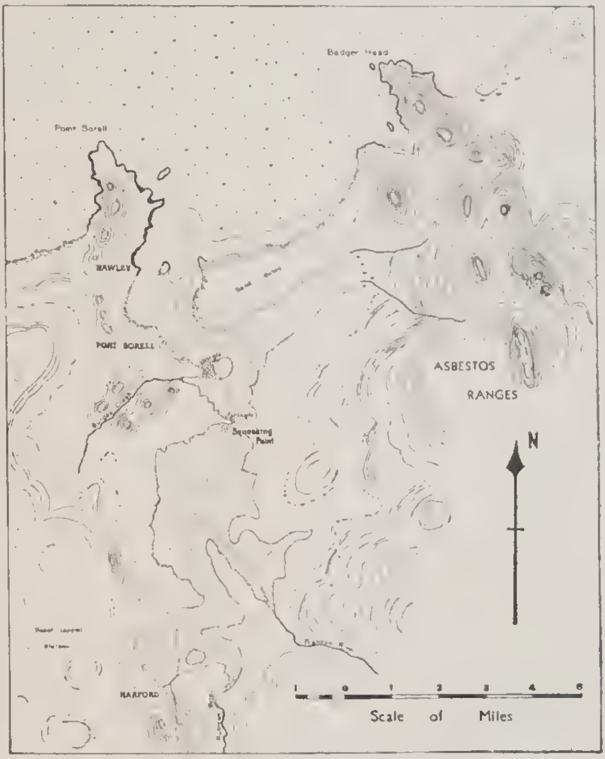

FIG. 4.—Map of Port Sorrell and the Rubicon Estuary (adapted from Admiralty Chart No. 1079, Folio 98).

above the present beach level, appears to be part of an old shore platform. The dolerite extends beneath the mouth of the estuary, and outcrops as a reef on the east side of the channel, and as an island, tied at low tide to the west bank, on the western edge of the channel. The island rises 10 to 15 feet above high water level.

A curving mid-bay bar, five miles long, extends from Badger Head to the eastern limit of the dolerite. The bar is about a mile wide, and is capped by sand dunes 30 to 40 feet high. Behind the bar extends an arm of the estuary, over three miles long, and from three-quarters of a mile to one mile wide, which provides some indication of the original depth of the bay. The growth of the bar has forced the estuary mouth over to the western side of the bay, where it has cut a channel through the dolerite, probably with the help of tidal scour.

Half a mile upstream from the Port Sorell jetty, there is a small island, rising a few feet above high tide level, and tied to the west bank at low water. The bed of the estuary here is composed of a light shingle of marine origin. The pebbles are of quartzite, and are apparently derived from the Asbestos Range. The island is built upon beds of this shingle that rise one to two feet above high water level. Presumably the shingle marks the position of a sea-beach formed before the mid-bay bar closed the bay. It may be an old beach ridge, or the fact that it occurs above high water may indicate slight uplift.

Two miles further upstream, at Squeaking Point, similar shingle is found, forming a flat bank about 10 feet above high water. Here, presumably, we have evidence of an emergence of this order. The shingle continues upstream for some distance. Going inland from Squeaking Point (westwards) a terrace 25 to 30 feet above the estuary level is encountered in a distance of about 100 yards. The upper surface of this terrace is sandy, and somewhat uneven. It continues inland until near Burges Creek, where there is a change to hilly country.

Five miles further upstream, where the State Highway from Devonport to Exeter crosses the Rubicon River, near Harford, the river, which is still tidal, has cut down to a depth of about 30 feet through an old flood plain which forms well marked high-level flats on either side of the estuary, and also on an island in midstream—left where a tributary joins the Rubicon a short distance downstream from the road bridge. This old flood plain appears to be contiguous with the higher terrace at Squeaking Point. Upstream from the Harford Bridge the river is incising a meander in the raised flood plain. This terracing may be taken as evidence of a repeated emergence of the coastal region of the orders of 10 and 30 feet.

Rocky Cape: West of Jacob's Boat Harbour the coast is formed of a belt of Pre-Cambrian quartzites, about seven miles wide. These rocks are highly resistant, and stand in relief as the Dip Ranges. Prior to the basalt extrusions these ranges formed a much more prominent divide than they do now, and they are still conspicuous. Along the seven miles of coastline to Rocky Cape the cliffs rise steeply from the water's edge, except near the mouth of Sisters Creek, where there is a belt of low sand dunes and quartz gravels, fronted by beach. A small island, Sisters Island, occurs off the coast at this point.

Rocky Cape itself is formed of particularly hard white quartzites which are strongly bedded and dip at about 45 degrees to the north. Prominent vertical joints cut across the bedding. In profile Rocky Cape consists of a series of blocks showing dip slopes to the north and steep scarp to the south (Pl. IX., fig. 2). Stephens (1908) considers that the scarps are due to faulting, but they may have developed from erosion of strongly jointed zones.

Two sea-caves at heights of 50 to 60 feet above sea-level occur at Rocky Cape. These caves, which have been described by Stephens (1908) are cut in cliffs of white quartzite. The strong bedding planes and intersecting vertical joints have defined the shape of the caves. The northernmost cave (Pl. IX., fig. 1) occurs in a cliff about 160 feet high. The cave is about 40 feet high at the entrance and 15 feet wide. It runs back into the cliff face for about 25 yards, the floor sloping gently upwards, and the roof coming down, while the cave narrows to about 3 feet wide. It appears to be about 60 feet above present sea-level, but this is somewhat misleading, because the floor is covered with a midden-deposit that is more than 10 feet thick. The cave opens to the west, and its portal faces the remnant of an old shore platform. Examination of this platform reveals sea-worn pebbles on its surface. These are readily distinguished from the markedly angular hill-wash of this region.

A second cave, facing towards Table Cape, occurs half a mile to the south of the first. It is of similar construction, except that the back of the cave is narrower, and the walls on either side are bedding plains dipping north. This cave is filled to a much greater depth with midden deposit in and about the entrance, so that it appears to stand 70 or 80 feet above sea-level, with a portal only 10 feet high. On going into the back of the cave about 50 feet, however, one descends nearly 20 feet in the sloping cleft, even though the floor is still covered with midden deposit. It follows that the cave floor cannot be more than about 50 feet above sea-level, and that its dimensions are of the order of those of the more northerly cave. Remnants of an old wave-cut bench at about the same level as the probable floor level of the cave form ridges that jut out for about 100 feet on either side of it, before descending abruptly to the sea. Cliffs, contiguous with the cliff in which the cave is cut, mark their landward terminations

West of Rocky Cape there is a wide deep bay, whose further headland was formed by the ridges of Cambro-Ordovician sediments west of the Detention River. This bay has been silted up, with the formation of a marshy lagoon behind the sand dunes of the bar. The dunes form a series of ridges varying in number from four to seven, parallel to the coastline. The ridges show gentle slopes to seaward, and steep slopes towards the marsh. Cliffs are being cut in the outermost dunes, exposing the roots of the trees along their crests, but there is no indication of a peat layer on the seaward side of the dunes, which appear to rest on a rock bench, and the fact that a patch of basalt, covered by a veneer of shingle occurs midway between the mouth of the Detention River and the road bridge, suggests that much of the marsh is underlain by a shore platform, at no great depth. Where the road bridge crosses the Detention River there is a depth of water of about 10 feet, due to the damming of the river by a sand-bar. The water surface is still 15 to 20 feet below the level of the sand ridges on either side however.

From Detention River to Black River the coastal features consist of old cliffs fronted by narrow strips of raised shore platform, or marshes fronted by sand-dunes, and irregular wave-cut benches of Cambro-Ordovician sediments interspersed with stretches of sandy beach. Black River, which is tidal for some distance upstream, has cut down to a depth of about 30 feet below the level of the flat sandy plain behind the lagoons at its mouth. This plain, which is 54 feet above sea-level at Black River railway station, appears to be a raised beach, elevated prior to the formation of the sand-bar which encloses the lagoons.

II. The Scarp Coast.

Devenport to Jacob's Boat Harbour: Between Point Sorell and Devonport a change in the nature of the coast is caused by the changed geology—the basalt plains which extend inland from the coast. Near Devonport, at the western end of Pardoe's Beach, the coast consists of a narrow coastal plain, formed by the emergence of a shore platform, backed by a scarp that is capped by basalt lava-flows; and these features continue almost without a break as far as Jacob's Boat Harbour.

The width of the coastal plain varies somewhat, widening to a mile or more on either side of the mouths of rivers like the Mersey, Leven, Forth, Emu and Inglis, and narrowing to as little as a hundred yards, or even less, in the intervening stretches. The line of the scarp is, therefore, sinuous. Where the coastal plain widens it is usually fronted by lines of sand dunes and storm beaches of shingle, and behind these barriers lagoons (usually drained) have developed to various extents. Where the plain narrows, the line of sand dunes may or may not continue, but generally the rocks forming the present wave-cut bench are exposed, either as a continuous bench backed by low cliffs cut in the raised platform, or as a discontinuous wave-cut bench, forming a series of small headlands separating strips of sandy beach. Along much of this coastline the rocks in which the waves are working are much-folded Cambro-Ordovician strata of varying hardness, and the wave-cut benches developed in these rocks are correspondingly irregular in shape and surface. Where, however, the bench is cut in softer Permo-Carboniferous sediments, as between Wynyard and Seabrook, the bench is a much more even surface, and only protrudes at low tide.

At the present cliff-line the coastal plain is 20 to 25 feet above sea-level. It rises gently inland, and is about 40 to 50 feet above sea-level near the foot of the scarp, which marks the old cliff line. Frequently the actual height at the foot of the scarp is more than 50 feet above sea-level, as a result of accumulation of hill-wash material.

Old rock stacks stand up above the general level of the plain at a number of points, as at Doctor's Rocks, and Woody Hill, between Burnie and Wynyard, and at Goat Island, near Ulverstone. Raised beaches of rounded boulders and coarse shingle form a veneer on the raised platform at the first two of these points, and a pebble beach is exposed at Sulphur Creek. More extensive raised beaches, which merge into flood plains, are found at the mouths of nearly all the rivers entering the sea along this stretch of coast; and most of the coastal townships are built upon these deposits.

Mersey River: The banks of the Mersey at Devonport rise to a height of 20 to 40 feet above the high-water level of the estuary, and are built partly of beach deposits and partly of silt. Upstream, as noted by Twelvetrees (1911), the Mersey valley contains well developed terraces 20 to 30 feet above the present flood plain, and these extend from Devonport to beyond Latrobe, a distance of more than four miles. Twelvetrees suggests that the region has been affected by repeated uplift because he observed traces of what he considered were still earlier flood plains in the Mersey valley.

At the western end of Devonport township is the small promontory of Mersey Bluff, which at some time may have formed the western headland of a deep bay now occupied by the coastal plain and estuary of the Mersey. This promontory is composed of Mesozoic dolerite, and formed part of a ridge separating two parallel valleys, now marked by basalt flows which pass below sea-level on either side of the Bluff. The Bluff was an island during the high sea-level periods, and now presents the appearance of a small tied island, but the sand dunes on the western side of the tombolo may mask a connection with a raised shore platform that runs from west of the Bluff to the mouth of the Don River.

The basalt on the eastern side of the Bluff is largely covered by beds of shingle to a height of about 20 feet above high water mark (Stephens, 1908). That on the western side forms the eastern headland of the Don Estuary, where it is covered with beach ridges of coarse basalt shingle. On the western side of the small estuary it forms the Don Heads, which is a line of cliffs, composed of more than one flow of basalt, marking the position of a deep, wide valley that passed well below present sea-level. Along this stretch of the coast the coastal plain is lacking, and the scarp coincides with the cliff-line. West of this basalt-filled valley the scarp recedes, and a narrow coastal plain develops again, and continues as far as Leith. A smaller basalt-filled valley passes below sea-level at the eastern end of Lillico's Beach, but the basalt residual is no longer connected to the basalt on top of the scarp.

Forth River: Paired terraces, about 30 feet above the level of the present flood plain of the river, extend for a distance of about nine miles up the Forth River from the township of Forth; and just below the bridge at Paloona is what appears to be a remnant of a second set of terraces at about 80 to 100 feet above the present flood plains. Below Forth township the flood plains widen, but the 30 foot terraces continue for a considerable distance downstream, particularly on the western side of the river, where it merges into the coastal plain that continues as far as Ulverstone. Between Forth and Leith, at the mouth of the estuary, there is a suggestion of a further terrace only a few feet above river level, but observations were not sufficient to confirm this. Leith, which is 40 feet above sea-level, is built on a coastal plain consisting of sand and shingle beds, grading at the coastline into storm beaches of shingle.

The mouth of the Forth Estuary was once a wide, deep bay, but it has been silted up into a flood plain as a result of the development of a bay-mouth bar from its western margin. This bar consists of a series of beach ridges of shingle, now several feet above high tide level, and covered by sand dunes about 20 feet high on their seaward side.

Leven River: At Ulverstone (50 feet above sea-level) the coastal plain, on which the town is built, becomes over a mile wide, and the section of it exposed in the banks of the Leven where the Nietta railway bridge crosses the river, shows 20 to 30 feet of silts and gravels at high water. This coastal plain decreases in height towards the sea, where it is fronted by sand dunes, and is not more than 10 to 15 feet above sea-level at the coastline.

Blythe and Emu Rivers: Between Ulverstone and Penguin the coastal plain is at first fronted by marshes (usually drained) formed behind the line of sand dunes that marks the cliff-line. Mid-way to Penguin, however, the Dial Ranges, which are composed of resistant Cambro-Ordovician sediments and formed a divide in the pre-basaltic landscape, come down to the coast, forming a high ridge almost at right angles to it. West of Penguin the Cambro-Ordovician sediments are capped by basalt, but they outcrop again as a ridge more or less parallel to the coast from Blythe Head to Wivenhoe. All along this stretch of the coast an irregular wave-cut bench marks the shore-face, and this bench is backed by a sharp cliff, 20 to 30 feet high, cut in the narrow raised shore platform which forms the coastal plain.

The Blythe River has cut down to a depth of about 25 feet near its mouth through a narrow plain composed of sands and gravels, and a similar flat, 30 feet above sea-level, occurs at Wivenhoe, the most easterly suburb of Burnie. Where the Emu River crosses this plain a section of bedded shingle and sand, 20 to 25 feet deep, is exposed.

Burnie Township: At Burnie there appear to be two raised shore platforms. Burnie Park (West Burnie) and much of the central part of the town is built on a short platform about 40 to 50 feet above sea-level, while Burnie Beach (from the piers to the Showground) is backed by a lower flat, about 15 feet above sea-level.

The Cam River: From West Burnie to Somerset the road runs along a narrow strip of coastal plain, which is fronted by low cliffs and a ragged wave-cut bench, formed in the folded and contorted Cambro-Ordovician sediments. At Somerset the mouth of the Cam has cut down to a depth of about 25 feet through bedded gravels (Pl. VIII., fig. 9), which form a terrace on either side of the river, and merge with the adjacent coastal plain. The shape of the pebbles suggests that this deposit is probably a raised beach.

Wynyard Plain: Between Somerset and Seabrook (22 feet above sea-level) the coastal plain widens to about a mile, and west of Seabrook the scarp develops a deep, wide indentation. In this indentation lies the Wynyard Plain, which is 40 to 60 feet above sea-level. It extends from the right bank of the Inglis River, southwards for one and a half miles, and eastwards to the northern edge of Woody Hill. The plain is composed of sands and clays, but east of Stinking Creek it changes to coarse shingle. Loftus Hills (1913) considers that the sands and clays represent a silted up estuary, or lagoon that formed behind the shingle beach. Where the Flowerdale and Inglis Rivers cross this plain, they have cut valleys to a depth of 30 to 40 feet below its surface, indicating an emergence of the land of this order since the formation of the plain.

The shore-face, in the vicinity of Wynyard, is cut in soft Permo-Carboniferous strata, which have been planed off to a more or less smooth platform, only exposed at low water.

Wynyard—Table Cape—Jacob's Boat Harbour: At Wynyard the coastline turns sharply to the north, as far as Table Cape, and then turns westwards again to Jacob's Boat Harbour. Table Cape is an uncovered laccolith of analcite-dolerite (trachydolerite, Twelvetrees, 1908), which has formed a buttress against marine erosion. This laccolith was uncovered before the adjacent basalt lava-flows were extruded, and they, in turn, are older than the Wynyard Plain, or the bay which it infills.

Between Wynyard and Table Cape these lavas overlie Tertiary and Permo-Carboniferous sediments, but west of Table Cape they pass below sea-level, and for a distance of about five miles the wave-cut bench and cliffs are formed of basalt. The cliffs rise over 200 feet high along this stretch, and are nearly vertical in their lower parts (Pl. IX., fig. 3). Approaching Jacob's Boat Harbour, the western wall of the old valley rises above sea-level, although several minor valleys, each filled by basalt, are encountered at sea-level before the Boat Harbour is reached.

At the Boat Harbour itself remnants of two shore platforms are preserved (Pl. IX., fig. 4). The higher one forms cliffs 20 to 30 feet high at the back of the beach, and extends back as a narrow gently sloping platform to the old sea-cliffs of the scarp, where it is about 50 feet above sea-level. The lower platform forms the flat-topped promontory, 300 yards long, and 50 yards wide, that protects the cove from the north-west wind. It is 10 to 15 feet above sea-level, and is being undercut at several places.

A further remnant of the upper platform occurs about half-a-mile east of the Boat Harbour, where a bluff of white quartzite, forming the interfluve between two of the smaller basalt-filled valleys that pass below sea-level, contains a niche which appears to be the remnant of a cave, at about 50 to 60 feet above sea-level. The cave—if it is one—is filled with angular debris from rock falls.

Stanley Peninsula: Stanley Peninsula (fig. 5) is a composite-tied island. The major part of the peninsula—the Green Hills—consists of a ridge of basalt (an old valley flow) tied to the mainland by a Y-tombolo, the lagoon of which has been drained (Pl. X., fig. 2). On either side of the tombolo, spits, which are about three miles long, have enclosed shallow arms of the sea. At low tide both inlets are dry except for central channels, which carry the drainage from streams flowing into them. A drain connects the inlets, and the workmen who dug the channel reported that the tombolo is underlain at a depth of a few feet by a bed of shells which is three feet thick. Excavations in other parts of the tombolo have confirmed this. In its narrowest part the tombolo is less than half-a-mile wide. Just within the mouth of the East Inlet a small spit has been built out in the reverse direction to the major spit.

The basalt ridge fills an old valley which sloped to the north, and passed below sea-level in that direction. Originally the basalt was probably connected with the extensive flows, now fronted by a scarp, in the vicinity of Forrest. Where the tombolo is situated, the valley floor, which was composed of soft Permo-Carboniferous (?) sediments, passed above sea-level. Marine erosion was able to undercut the basalt filling here, in the manner indicated in fig. 2, and so convert the northern part of the basalt flow into an island.

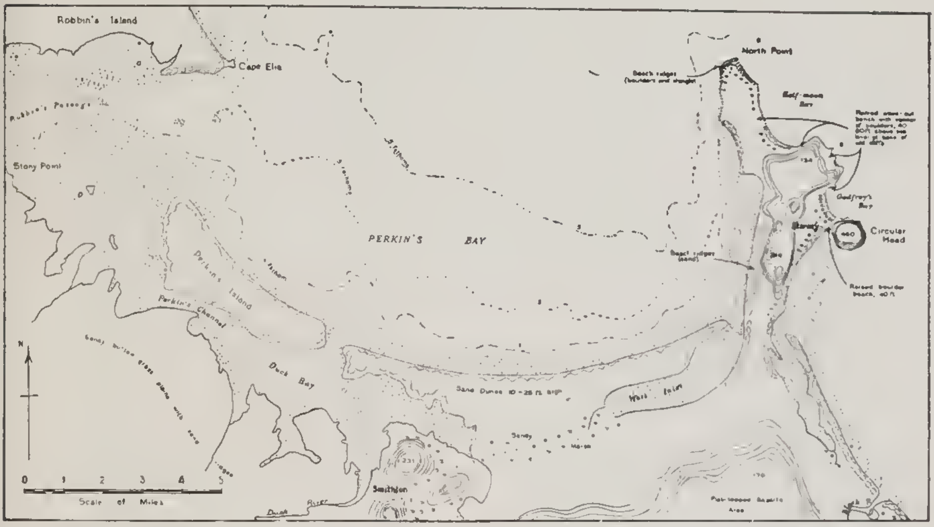

FIG. 5.—Map of Stanley Peninsula and Perkin's Bay (adapted from Admiralty Chart No. 3687. Folio 98).

On its western side the tombolo dies away about a mile north of its junction with the basalt ridge. About fifteen distinct sand ridges, separated by swales 2 to 3 feet deep occur on this part of it.

On its eastern side the sand bar and the low dunes which cap it extend as far as the township of Stanley, which is built in the shelter of Circular Head, and form part of the Y-tombolo which ties that one-time island to the Green Hills (Pl. X., fig. 1). The lagoon enclosed by this tombolo was still a swamp in 1826, when the Van Diemen's Land Company became established at Circular Head, but has since been drained. The shore platform beneath this tombolo is formed of a soft sandstone or mudstone, which outcrops at low tide at both ends of Godfrey's Beach, and also on the south-eastern side of Circular Head, between the old and the new wharves. The sand dunes backing Godfrey's Beach form a series of seven ridges, but this is largely due to the erection of brush fences, now buried, in an attempt to stem the landward advance of the sand. Two small streams, rising in springs and seepage at the foot of Green Hills, are conveyed in drains through the lagoon, until they lose themselves in the dunes, and a well at the western end of Godfrey's Beach, at the foot of the basalt ridge, supplies an abundance of good water, and was previously used for the town supply.

Basalt Ridge: The ridge consists of flows of basalt and olivine-nephelinite filling an old valley. At its southern end, where it is highest (250 feet above sea-level) the ridge is narrow and uneven, rising into several small eminences. Further north it broadens out into a level plain about 150 feet above sea-level. At the northern end the basalt passes below sea-level.

At the western end of Godfrey's Beach a junction of basalt with bedrock is exposed at low tide. The basalt is vesicular near the contact, and does not stand out in relief from the sediments. At about 15 feet from the contact it becomes dense and columnar, the columns being inclined at right angles to the slope of the valley wall. Finely laminated cross-jointing, at right angles to the axes of the columns, then becomes prominent, and enables the shape of the valley walls and floor to be determined. This valley, and another which joined it from the north-east, appear to have been tributaries to the main valley, which lay a little further to the west.

Where Godfrey's Beach meets the basalt ridge there is a remnant of an elevated shore platform, running up from 25 feet above sea-level at the present cliff, to about 40 feet at the old sea-cliff behind it. An exposure along the present cliff shows that this old bench is covered by a veneer of rounded boulders about 2 feet thick (Pl. VIII., fig. 8). The boulders include occasional pebbles of quartzite and reef quartz in addition to basalt and analcite-dolerite (from Circular Head). Half-a-mile further along the cliff there is a more extensive raised shore platform, about 30 feet above the present wave-cut bench, and running back to a height of 40 to 50 feet above sea-level (Pl. X., fig. 3). This bench also has a veneer of rounded pebbles. Rock-stacks have been cut from it in one or two places, and islets and rocks some hundreds of yards out to sea testify to the further extension of this shore platform—and of the basalt-filled valley—further out to sea. The present wave-cut bench is being formed in a layer of vesicular basalt, which has enabled the waves to undermine the more dense basalt in places, cutting small caves, a miniature arch, and, near the northern end of the raised platform, a small blow-hole.

Turning the point into Half-Moon Bay, still further traces of this raised shore platform can be observed (Pl. VIII., fig. 7), until the southern edge of that part of the Peninsula known as the Western Plain is met. On the western side of the Green Hills, further indication of emergence is found. The western shore is fronted with a beach almost half a mile wide at low tide, and as a result there is little wave erosion, or cliff formation along this stretch of the coast. The back of the beach is marked by a few pebbles, and a line of miniature sand dunes, which enclose a lagoon about 20 yards wide. From this lagoon there is a sharp rise of the land of from 15 to 20 feet in a matter of a few yards, and then a narrow sloping plain rising to about 50 feet above sea-level in about 100 yards. The slope then steepens to the steep side of the basalt ridge. This raised strip of plain, which runs along the whole western side of the Green Hills appears to be an old shore platform.

Western Plains: The Western Plains (Pl. X., fig. 4) form a low-lying north-westerly extension of the peninsula, about three miles long, and one mile wide. Where it joins on to the Green Hills it is faced by a scarp as marked as that along either side of the basalt ridge elsewhere. The surface of the plain is not wholly flat, and in its central part there are one or two gentle hills that rise to 70 to 80 feet above sea-level, and show an occasional outcrop of large angular boulders of basalt. Midway along the north-eastern shore, there is a cliff face, about 20 feet high, in which decomposed basalt is overlain by a veneer of rounded pebbles and boulders similar to those overlying the raised platform at the western end of Godfrey's Beach. This veneer is about 3 feet thick, and contains occasional pebbles of quartzite. There can be little doubt, therefore, that this is an old raised shore-platform and pebble beach. The surface of the platform and beach rises inshore to a height of about 35 to 40 feet. The probability is, therefore, that the Western Plains are largely a raised shore platform cut in a basalt-filled valley which passed below present sea-level, and was a tributary to the main Green Hills valley.

Much of the Western Plains, however, is of secondary origin. All along the north-eastern, and along a considerable extent of the south-western shore, extensive beach ridges of pebbles and boulders of basalt have been built up to a height of 15 feet above sea-level (Pl. VIII., fig. 10). The successive ridges are occasionally as wide as 20 feet, and are separated by swales 2 to 3 feet deep. In the vicinity of North Point, a series of such ridges has been built up to a total width of about 200 yards. Sand has accumulated to some extent behind these ridges, but the wind is too strong for dunes to form, except where the plain meets the Green Hills ridge. However, quite extensive marshes and lagoons have formed behind the pebble ridges, especially in the northern part of the plains. Kelp and seaweed act as the cementing medium to the pebbles. In places one can observe the old shore platform descending abruptly to these pebble beaches, almost as a cliff.

Circular Head (The Nut): Circular Head is the remains of a small steep-sided laccolith. It consists of gigantic columns of analcite olivine-dolerite, 4 to 6 feet in diameter, and rising to a height of 400 feet above sea-level. The columns are vertical, and in places form vertical cliffs several hundred feet high, with a fringe of steeply sloping scree around their lowest part (Pl. IX., fig. 1).

The top of the Circular Head is not as flat as appears from a distance, and two small valleys, which junction, form a hanging valley about 80 feet deep on the southern side, indicating that a valley ran in that direction prior to the erosion of the sedimentary walls of the laccolith.

Stanley is built on an old pebble beach, 30 to 40 feet above sea-level, at the foot of the Head. Limpets have been found associated with the pebbles (Nye, 1938, p. 8), and two such shells were secured from excavations in progress in the basement of the Post Office, in association with water worn pebbles. This material may not have been *in situ,* however.

Receding Spit and Siltation of Stanley Harbour: The Eastern Spit is receding. Mr. Partridge, the editor of the *Circular Head Chronicle,* informed me that it has receded about half-a-mile during his fifteen years of residence at Stanley. This recession appears to have been in progress for a considerable period. Thus Stephens (1908, p. 765) states that whereas the original track to Stanley followed the East Spit, and easily forded the bar across the mouth of the inlet at low tide, by 1908 (or earlier) the channel had deepened so that travellers had to strike inland after crossing the Black River, and follow the tombolo.

If the recession of the spit continues, it will leave the tombolo, which carries the road and railway, exposed to the action of storm waves at its narrowest part. Efforts are being made to stem the recession by planting marram grass along it, but if, as seems probable, the recession is due to wave action rather than the wind, and is related to the stage which the coast line has reached in its development, these efforts will meet with little success.

The sand from this receding spit is being carried northwards, and is silting up Stanley Harbour, at the rate of about one inch a year, according to a report issued by the Marine Board, about 40 years ago. This conforms with the fact that the ship *Caroline,* of 330 tons burden, which came to Stanley in 1828 (Hare, 1928) berthed at the inside part of the old wharf, where to-day a small yacht can barely find sufficient water at high tide, and where the sand is bare at low tide. Since the *Caroline* would draw at least 8 feet of water, and would probably require a foot or two of water to spare, at least 96 inches of sand have been deposited in the last 100 years. Bathing boxes which were in use fifteen years ago are now so far removed from water deep enough to swim in, even at high tide, that they have been abandoned; and the place where it is reported that a 300-ton schooner was built and launched in the early days is now about 100 yards from the high tide mark.

Godfrey's Beach, on the other hand, does not appear to be silting up, and the sand dunes are sometimes subject to attack by storm waves. Thus a storm during Easter, 1939, swept away

30 feet of dunes. Wind is constantly blowing the sand inshore; and the storms, according as they come from the north-west or the north-east, shift the sand from one end of the beach to the other. This trend has been active since 1837 (Gunn, 1854).

III. The Emergent Coastline.

Perkin's Bay: The sand bar which forms the three mile long spit on the west side of Stanley Peninsula (fig. 5) continues westwards in an unbroken curve as far as the mouth of the Duck River, a distance of eight miles. At its western end, as at the eastern, the bar forms a spit about three miles long, here enclosing the eastern arm of Duck Bay. On the other side of the narrow channel through which the Duck River discharges into Perkin's Bay, the sand bar forms again as the dune-covered Perkin's Island (wrongly shown on geological maps of Tasmania as composed of basalt), and continues in the same sweeping curve for another four and a half miles, as far as Robbins' Passage. Between the bar and the mainland is a channel from half-a-mile to a mile and a half wide, which is very shallow, being largely exposed sand at low tide; and for a distance of about three miles, between the east arm of Duck Bay and West Inlet, the channel has been converted into a sandy marsh, which joins the bar to the mainland. The excessive silting and sanding up of this stretch of the channel is probably due to the fact that this strip of the bar is most exposed to strong winds from the sea, whereas other parts of the bar are relatively sheltered by Stanley Peninsula and Robbins Island.

On the seaward side, soundings show that the sea-floor is very shallow, and has a very gentle slope. The presumption is, therefore, that this bar is an off-shore bar which has been joined to the mainland by silting of part of its lagoon. The breach in the bar at the mouth of the Duck River appears to be stationary, but the disposition of sand off the mouth suggests that a certain amount of westerly beach-drifting is in progress.

The origin of the bar is, no doubt, related to the features of recent emergence described in the next section.

Smithton to Woolnorth and Marrawah: Between Smithton (Duck River) and Woolnorth Point and Marrawah, the compound nature of the coast is prominent. In plan the coast has the outline of a relatively youthful coast of submergence (fig. 6). Drowned river mouths and off-shore islands of various sizes point to drowning of an extensive river system.

Siltation of the estuaries, followed by emergence, has given rise to an extensive coastal plain 20 to 25 feet above sea-level, which rises gently to 50 feet or more as it is followed inland. The plain extends inland for several miles in places, and merges into a series of five large swamps—Mowbray Swamp (two arms), Briton Swamp, Montague Swamp and Welcome Swamp, each of which is about 100 feet above sea-level where crossed by the

Smithton-Marrawah road. These swamps are separated from one another by ridges rising 100 to 200 feet above the level of the swamps. The most easterly of them, the Christmas Hills, is the most prominent, and is capped in places by basalt. The Welcome Swamp on its west side abuts against the basalt capped plateau (The South Downs) near Marrawah.

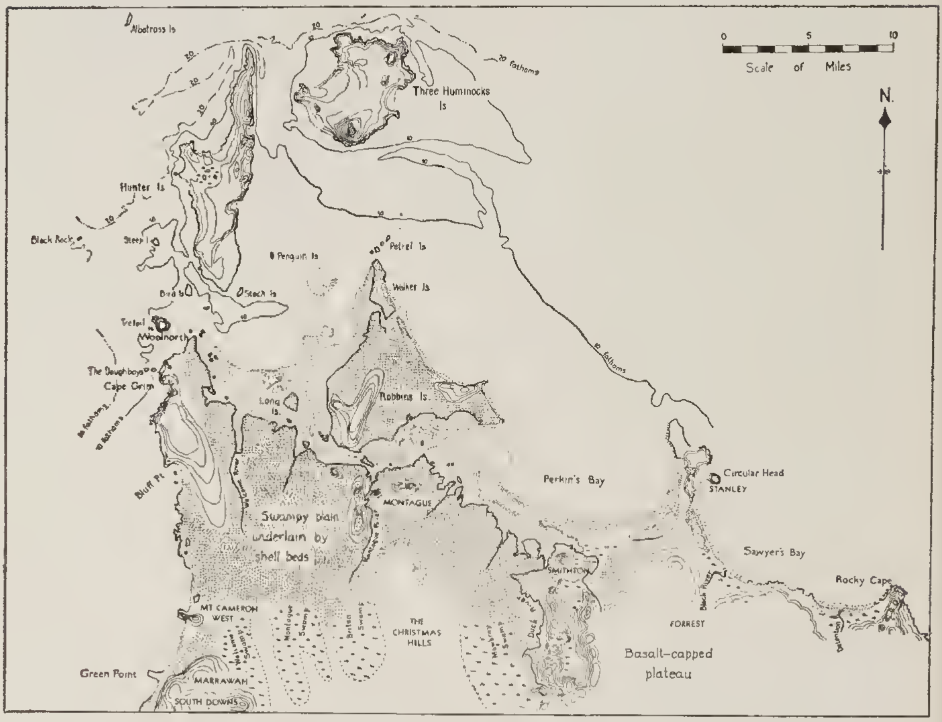

Fig. 6.—Map of the Emergent Coast, west of Smithton (adapted from Admiralty Chart No. 3687, Folio 98).

The thickness of the sands forming the plain, and the shape of the underlying bedrock are unknown, but in places along the Duck River the sands are only 15 feet thick. Marine shells, regarded as Pleistocene, have been found at depths of 6 to 10 feet at various parts of the plain, near Smithton (Nye, 1934), and in the vicinity of the Welcome River, while freshwater shells and marsupial remains were found associated with peat during the draining of the eastern arm of Mowbray Swamp (Nye, 1934, pp. 59, 60 and refs.); so that while marine conditions dominated near the mouth of the original bay, they gave way to estuarine conditions towards the bay head. A similar gradation has been observed on the Deep Creek Plain, east of Smithton (Nye, 1934). These two contemporaneous plains are separated by a long ridge of resistant dolerite dyke and its adjacent sedimentary wall rocks (Pl. IX., fig. 7). The Deep Creek Plain rises about 100 feet above sea-level, and this leads Nye (1934, p. 61) to suppose that the Duck River Plain also may have been higher originally, but may have undergone erosion since its emergence. The presence of old dune ridges on the Duck River Plain, and on the stretch of plain between Montague and Woolnorth Point, suggests, however, that the present surface is more or less the original one.

The Duck River flows in a meandering course across the plain, near Smithton, and has cut down its bed to a depth of 15 to 20 feet into the sands and underlying bedrock, but has not formed flood plains at the new level. Deep Creek, on the other hand, has formed a small flood plain, or marsh, below the level of the plain, at its mouth.

The level of the coastal plain is broken by isolated sand ridges trending more or less parallel to the coastline, and by occasional ridges of older rocks rising 200 to 400 feet above sea-level. These ridges of older rocks may be designated resumed islands since, prior to the emergence of the coastal plain they formed coastal islands similar to those in existence off the present coastline (fig. 6), and were restored to the mainland by the emergence rather than by any silting process. Such resumed islands are represented by the basalt-capped hills on which the village of Montague is built; the basalt ridge at Montague West; the adjacent hills of Cambro-Ordovician sediments; the high land stretching southwards from Woolnorth Point to Bluff Point, and fronting the sea with the precipitous cliffs of Cape Grim; the small dome-shaped laccolith of Mt. Cameron West (Pl. X., fig. 5); and possibly the basalt-capped plateau of the South Downs at Marrawah. Two similar resumed islands, formed of basalt ridges, occur on Robbins Island, surrounded by a similar emergent plain.

Woolnorth Point: Just west of Woolnorth Station are the remains of old rock stacks and sea-cliffs, cut in Cambro-Ordovician sediments, and fronted by indurated beach or dune sands, which form a narrow coastal plain 40 to 50 feet above sea-level. The present shore consists of an irregular wave-cut bench, cut in steeply dipping sediments, interspersed with pocket beaches. Close to Woolnorth Point a series of beach ridges of shingle about 80 yards wide have been built up to a height of 5 to 6 feet above high water mark (Pl. IX., fig. 8). The pebbles are chiefly of olivine-basalt, presumably derived from Robbins Island, or from some of the smaller islets off the coast, whose geological characters are not shown on geological maps. The ridges are 3 to 4 feet wide, and separated by swales 1 to 2 feet deep. The inner ridges tend to be grass-covered, and lead back to low cliffs cut in the raised shore platform.

The old sea-cliffs west of Woolnorth Station mark the northern end of the large resumed island that extends southwards as far as Studland Bay (fig. 6). Along its western side this island is exposed to the south-west winds which bring frequent heavy storms against the shore. Marine erosion has destroyed all trace of the coastal plain on this side of the resumed island, and has cut steep cliffs, up to 200 feet high, in the higher land of the old island (Pl. IX., fig. 5). The cliffs are being undermined, with the formation of caves, and their rapid recession is attested to by the occurrence of the Doughboy Islets, off Cape Grim (Pl. IX., fig. 6). These two islets were attached to the mainland at no distant date, but the sea has cut channels between them and the mainland.

Trefoil Island, some distance to the north-west, has a similar cliffed coastline.

Marrawah: A beach four miles long stretches from Green Point, west of Marrawah township, northwards to Mount Cameron West, which is a small, steep-sided laccolith of analcite-olivine dolerite (Pl. X., fig. 5). Sand dunes extend the length of the bay, rising as high as 60 feet in its central part. Behind the dunes are the extensive marshes of the coastal plain, which extends back to a steep scarp about 300 feet high. The scarp consists of old sediments capped by an unknown thickness of Miocene limestone, and about 100 feet of basalt. Remnants of an old shore-platform about 50 feet above sea-level can be observed in places at the foot of the scarp.

Green Point appears to be a tied island, joined to the mainland by a Y-tombolo which encloses a small marshy lagoon, but there may be a rock connexion with the mainland beneath the sand dunes on the northern side of the tombolo. Green Point itself appears to be another remnant of the raised shore platforms found at the foot of the scarp.

At the southern end of the beach leading to Mt. Cameron West, the dunes are intact, but at the northern end they are subject to strong south-westerly winds, and the sand has been blown inland for a distance of over a mile. This has exposed beds of a Recent shelly limestone beneath the dunes. Exposure has been aided by wave erosion, which has cut a cliff in the dunes and limestone adjacent to Mount Cameron West.

The limestone consists of sand and comminuted shell fragments with occasional whole shells. Adjacent to Mt. Cameron West its top is 25 to 30 feet above sea-level, but a gentle southerly dip carries it below sea-level in about half a mile. The limestone is brownish coloured, compared with the white to earthy-white colour of the dunes, and the upper beds have been indurated with limonite and lime, the latter mostly in the form of tubular calcareous concretions. The indurated beds stand out in relief as the result of wind etching. Close to Mount Cameron West, where there is a rapid run-off for rain water, the limestone has been eroded into a small area of badlands. At this point the sandy cover has been stripped completely from it. The fossil content of these beds (recorded in the Appendix) proves that they are of Quaternary age, so that their present position above sea-level indicates an emergence of the shore line in relatively recent time. Similar beds occur on the north side of Mt. Cameron West, and also at a distanee of about two miles north of the Mount, at a similar elevation above sea-level (Meston, 1932).

North of Mt. Cameron West are further beaches, divided at intervals by reefs of roek (projecting wave-cut benches) and backed by sand dunes. The dunes are being blown inland into the swamps that extend for some miles behind them, and euspate lagoons, or lakes, lie between the swamps and the inner fringes of sand.

Springs of fresh-water occur on the part of the beach exposed at low tide at two points between Green Point and Mt. Cameron West. At one place one spring was observed (close to the Marrawah picnic ground), while at the other seven springs formed a cluster. The drainage from the marsh behind the dunes apparently seeps through the sand along the surfaee of the buried shore-platform, and when the "head" becomes sufficient, issues as springs on the sea-side of the dunes, causing the sand to "boil" in small circular depressions which overflow to the sea. The largest pool measured 3 feet in diameter. The relation of these springs to the shore-platform suggests that the shore-platform continues for a considerable distance inland, as the floor of the marshes.

Towards the northern end of the beach, where wind aetion is stronger, the heavy seas have thrown up a storm beach of pebbles and boulders, and where these have filled the mouths of streams through the sand dunes, permanent waterways are maintained, for even when the pebble-filled stream mouths are covered over with sand, the water can easily percolate between the pebbles. As a result the streams at this end of the beach are not blocked by intermittent sand-bars as is found more usually along the Tasmanian coast.

The Raised Shorelines.

The observations given above indicate that remnants of at least two raised shorelines can be found at intervals along the north-west coast of Tasmania, one at 5 to 15 feet above sea level, and the other at 40 to 50 feet above it, thus confirming the observations of Lewis (1934, p. 82); and that a number of the rivers flowing into Bass Strait along this stretch of coast show a development of terraces in their valleys at corresponding heights above their present levels.

The 40 to 50 feet strandline is the more pronounced of the two, and can be traced from the Rubicon Estuary as far as Marrawah. The 5 to 15 feet strandline is more difficult to establish. In many places there are wide shingle beaches up to 10 feet, or even more, above sea-level. These beaches fall steeply to the water-line, and sometimes lagoons are impounded behind them, but it is probable that many, if not all, of them have been formed by storm waves acting at present sea-level. Some doubt must also attach to wave-cut benches which project only a few feet above normal tide level. Such benches could be due to storm waves as easily as to emergence. At some localities, however, as at Jacob's Boat Harbour, there are undoubted remnants of the 15 feet strandline.

There is also a suggestion, in the form of doubtful river terrace remnants in the Mersey and Forth valleys, of the existence of a third strandline at about 100 feet above present sea-level, but this could not be confirmed.

The occurrence of raised beaches and shore platforms along the northern coast of Tasmania and the islands of Bass Strait was first recorded by Johnston (1888), who noted the occurrence of *Helicidae* sandstones at heights up to 100 feet above sea-level on Cape Barren Island, Badger Island, Chappell Island, Green Island and Kangaroo Island, in the Furneaux Group, and a raised beach about 100 feet above sea-level on Chappell Island. On Badger and Green Islands he recorded a series of shelly beaches invariably 40 to 50 feet above sea-level, and sometimes nearly a mile from the shore, while on Flinders Island he found a stratified bed of oyster shells in the banks of the Arthur River, about two miles above its mouth, and 30 feet above sea-level. In addition he noted comparable features " on other places along the northern coast of Tasmania," as well as " subordinate valleys within main ones," and river terraces in the valleys of the chief rivers debouching into Bass Strait. Later workers have confirmed Johnston's observations. Twelvetrees (1908, p. 165) states that raised beaches " exist all along the northern coastline and in the Straits islands. Elevated beaches of marine shingle are seen at the mouths of the Blythe and Emu Rivers, and elsewhere along the shore of Bass Strait." Lewis and Nye (1928, p. 27) write that " the whole coast shows a recent uplift, and a very marked shore platform exists, particularly from Devonport to Stanley." David (1923) has recorded a raised beach 3 to 4 feet above high-water on the Tamar, near Launceston; and Lewis (1934) records raised beaches at 5-15 feet and 40 feet above sea-level in the vicinity of Burnie.

Submerged Shorelines.

Evidence points to the existence of at least one, and probably two, submerged shorelines. The submarine contours of the Tamar Valley can be traced on Admiralty Chart No. 3649, Folio 98, for a distance of 3 to 4 miles out to sea. The valley form can be followed to a depth of 15 fathoms, and with less certainty to the 20-fathom contour, indicating the existence of a submerged shoreline at a depth of about 120 feet below sea-level. Similarly, in the vicinity of Hunter Island and Three Hummocks Island, in the extreme north-west (fig. 6), the contours of submerged valleys can be traced on the Admiralty Chart, No. 3649, Folio 98.

to depths of 25 fathoms, but apparently do not continue to greater depths. Here, then, the submerged shoreline lies at about 150 feet below sea-level.

The many basalt-filled valleys that pass below present sea-level provide further evidence of a submerged shoreline some distance out to sea from the present coastline; but there is a suggestion that this shoreline is older than the 120 to 150 feet submerged shoreline. Thus, if the basalts in the Stanley-Smithton-Montague district are regarded as of similar age, then the basalt-filled valleys on Robbins Island must be older than the submerged valleys that lie between Robbins Island and Hunter and Three Hummocks Islands. Again, the Tamar has breached a basalt flow extending from Beauty Point via Garron Rock to near Georgetown. The base of this flow, whose valley section is clearly shown at Beauty Point, lies well below the present estuary level, but above its floor. Again, the basalt-filled valleys in the Wynyard-Table Cape district are considerably older than the valley which was drowned to give rise to the Wynyard Plain. No depth can be suggested for this possibly older shoreline.

Origin of the Oscillating Shorelines.

It seems highly probable that these movements in the position of the shoreline are directly related to the eustatic rise and fall of sea-level during Glacial and Post-Glacial time. Lewis (1934) from his studies of the river terraces in the valley of the Derwent and other rivers in south-eastern Tasmania has shown that a definite sequence of alternating periods of high sea-level and low sea-level can be established in that part of Tasmania. During the periods of high sea-level flood plains were formed at heights of 100 to 150 feet, 25 to 60 feet, and 5 to 15 feet, respectively, above present river level. During the intervening periods of low sea-level, troughs were cut in the respective flood plains to depths of 250 feet, 100 feet, and 20 feet, in each case leaving residuals of the former flood plains as paired terraces. He concluded that these terraces were the outcome of the eustatic changes of sea-level during the Pleistocene and that the raised shorelines at 100 feet, 40 to 50 feet, and 10 to 15 feet, above sea-level, which he and other observers had noted, particularly along the northern coast of Tasmania and the islands of Bass Strait, were developed contemporaneously with the river terraces during the high sea-levels of the interglacial stages. On this basis he correlated the three series of river terraces and raised shorelines with the known glacial stages in Tasmania, as follows:—

Terrace System.	Age Correlation.
Uppermost terraces and beaches 100-150 ft. above sea-level.	Pre-Glacial sea-level (Pre-Malanna).
Middle terraces and beaches 45-50 ft. above sea-level.	Malanna-Yolande sea-level.
Lowest terraces and beaches 5-10 ft. above sea level.	Yolande-Margaret sea-level.

This is to assume that the Pleistocene glacial stages in Tasmania were contemporaneous with the glacial stages in other parts of the world. This may well have been so; but it is clear that the amount of ice involved in the glaciation of Tasmania, even at its maximum, would not have caused an eustatic rise and fall of sea-level of the magnitude concerned. Assuming that ice covered an area of 25,000 square kilometres of Tasmania to the improbable depth of 2,000 metres, then the amount of water involved would be of the order of a layer 10 centimetres thick over the surface of the ocean. In other words, the eustatic changes of sea-level which affected Tasmanian river-valleys and shore-lines were independent of the glaciation of Tasmania, and are to be correlated, therefore, with the glacial stages of the Great Ice Caps. Whether these existed contemporaneously in the Northern and Southern Hemispheres remains to be proved, but if one waxed while the other waned, then (i) the maximum possible eustatic change of sea-level would have been reduced accordingly; and (ii) the duration of the periods of high and low sea-level would have been prolonged. In view of the magnitude of the observable changes of sea-level, there can be little doubt as to the broad contemporaneity of the successive glacial and interglacial stages throughout the world.

It follows then, that though Lewis was probably right in ascribing the changes of sea-level to this cause, the river terraces and marine terraces of Tasmania must be correlated with the stages of the Pleistocene as revealed in North America and Northern Europe, rather than as revealed in Tasmania, where the record is not complete. On this ground it is necessary to account for three interglacial periods of high sea-level, rather than two. Moreover, as Daly (1934) has shown, there is considerable evidence of a further eustatic fall of sea-level in Post-Glacial time, of the order of 15 to 20 feet, so that if the record is complete, we should have four sets of terraces to search for, rather than the two implied by the glacial record in Tasmania.

If Daly is correct, it seems likely that the 5 to 15 feet terraces and shore platforms have developed from the Post-Glacial fall of sea-level, in which case the 40 to 50 feet strandline may correspond to the Third Interglacial Stage (Riss-Würm), and the 100 to 150 feet strandline to the Second Interglacial Stage (Mindel-Riss). Their heights above sea-level are about the correct magnitude, judging from the figures given by Daly (1934) for such terraces in Europe, Northern Africa and Northern America.

Of the two submerged shorelines recognized in the present study, the one at 120 to 150 feet below sea-level corresponds in magnitude to the first fall of sea-level measured by Lewis (1934) in the Derwent Valley, and is older than the 40 to 50 feet raised strandline, but presumably younger than the 100 to 150 feet raised strandline. It would correspond, therefore, on the suggested correlation, to the Third or Riss Glacial Stage. The pre-basaltic submerged strandline would correspond to an earlier Glacial Stage. In the Wynyard district the pre-basaltic valleys cannot be younger than the Second Glacial Stage, since the Wynyard Plain was formed in a valley cut in the basalts. The occurrence of what appears to be a remnant of a 100-feet terrace at Paloona in the Forth Valley suggests that the Forth Valley was formed during the Second or Mindel Glacial Stage. If this was so, the fact that the Forth Valley cut through the basalt sheet capping the plateau, and extending to the coastal scarp, suggests that the basalt-filled valleys passing below sea-level were probably formed during the First or Günz Glacial Stage. This suggestion must be accepted with considerable caution, however, since the basalt-filled valleys might have been brought to their present position by extensive Inter-Glacial faulting, parallel with the coastline, but located some distance inland from it.

Appendix.

Fossil Assemblage from raised beach deposit immediately south of Mt. Cameron West, near Marrawah (N.W. Tasmania).

FORAMINIFERA (determined by W. J. Parr).

Gaudryina cf. *hastata* Parr.
Triloculina insignis (Brady).
Triloculina trigonula (Lamarck).
Bolivina sp.
Discorbis dimidiatus (Jones and Parker).
Discorbis australensis Heron-Allen and Earland.
Cibicides sp. aff. *pseudoungerianus* (Cushman).
Elphidium imperatrix (Brady).
Elphidium macellum (Fichtel and Moll).

BRYOZOA (Determined by L. W. Stach).

Crisia acropora Busk.
Cellaria setigera Pergens.
Cellaria tenuirostris (Busk).
Vittaticella crystallina (Thomson).
Scuticella ventricosa (Busk).
Adeonellopsis sp.
Retepora sp.

ECHINOIDEA (Determined by L. W. Stach).

Amblypneustes ovum pachista Clark.

The assemblages listed above are characteristic of recent shore deposits from the south-eastern Australian coast.

In addition to the above forms, the following contemporaneous land forms, presumably wind blown, were present.

MOLLUSCA (Determined by C. J. Gabriel).

Laoma penolensis Cox.
Succinea australis Ferussac.
Charopa albanensis Cox.
Flammulina marchianae Cox.

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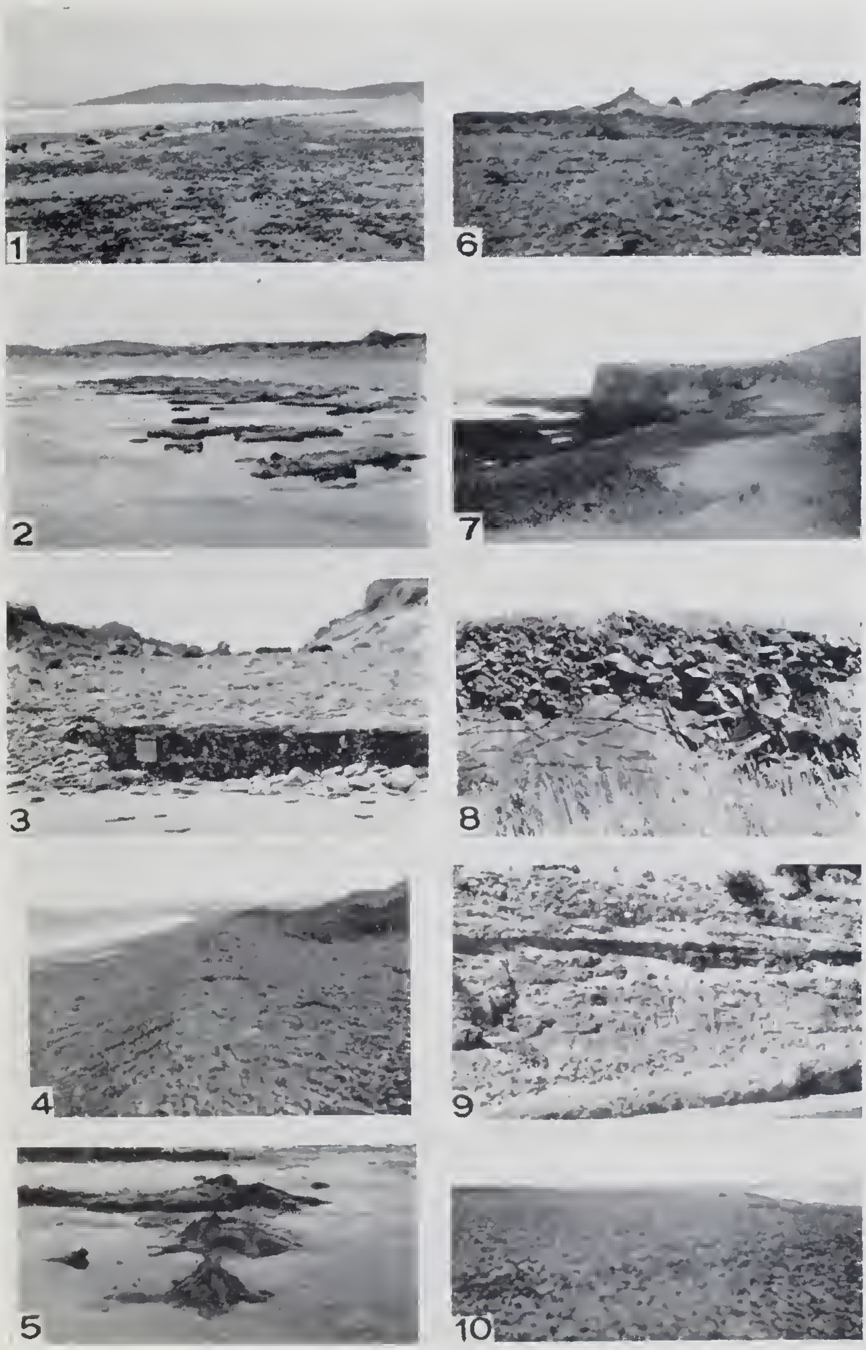
Explanation of Plates.

PLATE VIII.

1. Tree stumps outcropping at low tide at Badger Head Bay, with West Head in the background.
2. Bed of peat outcropping at low tide at Badger Head Bay, with dune remnants capping the low cliff in the background.
3. Bed of peat outcropping beneath the storm beach, on its seaward side, Badger Head Bay.
4. Shingle ridge thrown up by storms, on the backshore at Badger Head Bay.
5. Close view of the tree stumps shown in Fig. 1 above.
6. The transition from stationary dunes to eroded dunes, where the dunes become exposed to westerly winds blowing past Badger Head.
7. Raised shore platform, 30 to 40 feet above sea-level, at the south-eastern end of Half-Moon Bay, Stanley Peninsula.
8. Raised boulder beach capping the remnant of raised shore platform at the western end of Godfrey's Beach, Stanley Peninsula.
9. Section of raised shingle exposed in the road cutting at the Cam River.
10. Beach ridges of shingle near North Point, Stanley Peninsula.



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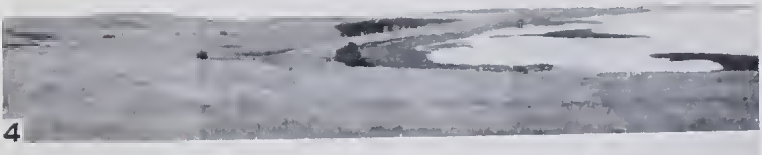

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Plate IX.

1. Raised sea cave, 50–60 feet above sea-level, at Rocky Cape.
2. Rocky Cape, from midway between the Black and Detention Rivers, showing the dip slopes towards the sea, and scarp slopes to the south.
3. Coastline between Table Cape and Jacob's Boat Harbour, where the basalt passes below sea-level. Rocky Cape can be seen in the background.
4. Jacob's Boat Harbour, showing the occurrence of two raised shore platforms, one at 10–15 feet above sea-level, the other at 40–50 feet, backed by a basalt-capped scarp, representing the old cliff line.
5. Cape Grim, showing the active formation of caves at present sea-level.
6. The Doughboys, off Cape Grim.
7. The Duck River Plain, where it abuts against the scarp formed by the dolerite ridge running south from Smithton. The scarp, in part at least, represents old sea-cliffs.
8. Shingle ridges near Woolnorth Point, with a raised shore platform in the background.

Plate X.

1. Circular Head, Stanley, an analcite-olivine-dolerite laccolith, joined to the main part of Stanley Peninsula (right) by a Y-tombolo. The hedge in the right middle-ground marks the edge of a raised shore platform.
2. The main basalt ridge of Stanley Peninsula (The Green Hills) tied to the mainland by a narrow tombolo. Portions of the spits on either side of the tombolo can be seen.
3. Raised shore platform, with capping of boulder beach, where the Green Hills basalt passes below sea-level, Stanley Peninsula.
4. The Western Plains, Stanley Peninsula, near their junction with the Green Hills ridge. A shingle ridge, capped by sand dunes, has enclosed a small lagoon, now drained, near the seaward edge of the raised shore platform, and the curved spits of shingle are building out the shore.
5. Mount Cameron West, a "resumed" island formed by a laccolith of analcite-olivine-dolerite, from the south. Remains of a raised shore platform can be seen on the seaward side of the headland. The dunes adjacent to the mount cap beds of Recent limestone that have been raised 25–30 feet above sea-level.